Trace gas analysis in biomass gasification

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Trace gas analysis in biomass gasification

PhD project of Helge Grosch

1. December 2011

At the CHEC research center of DTU Chemical Engineering

June 14th 2012

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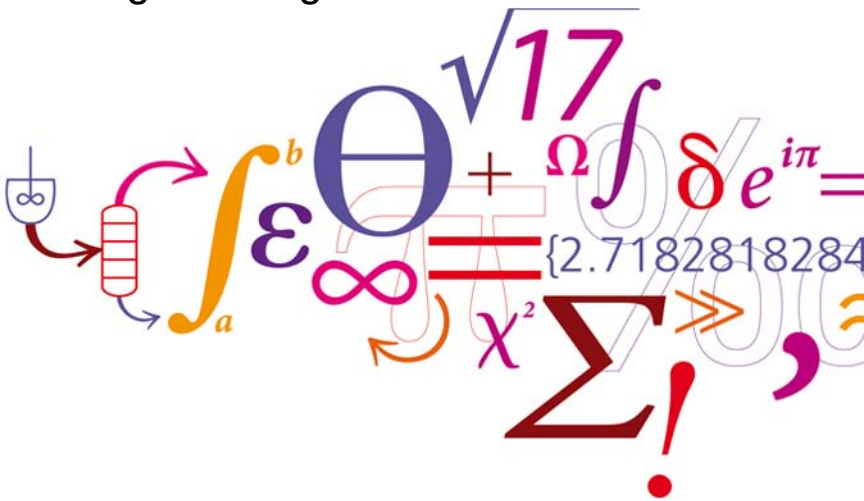
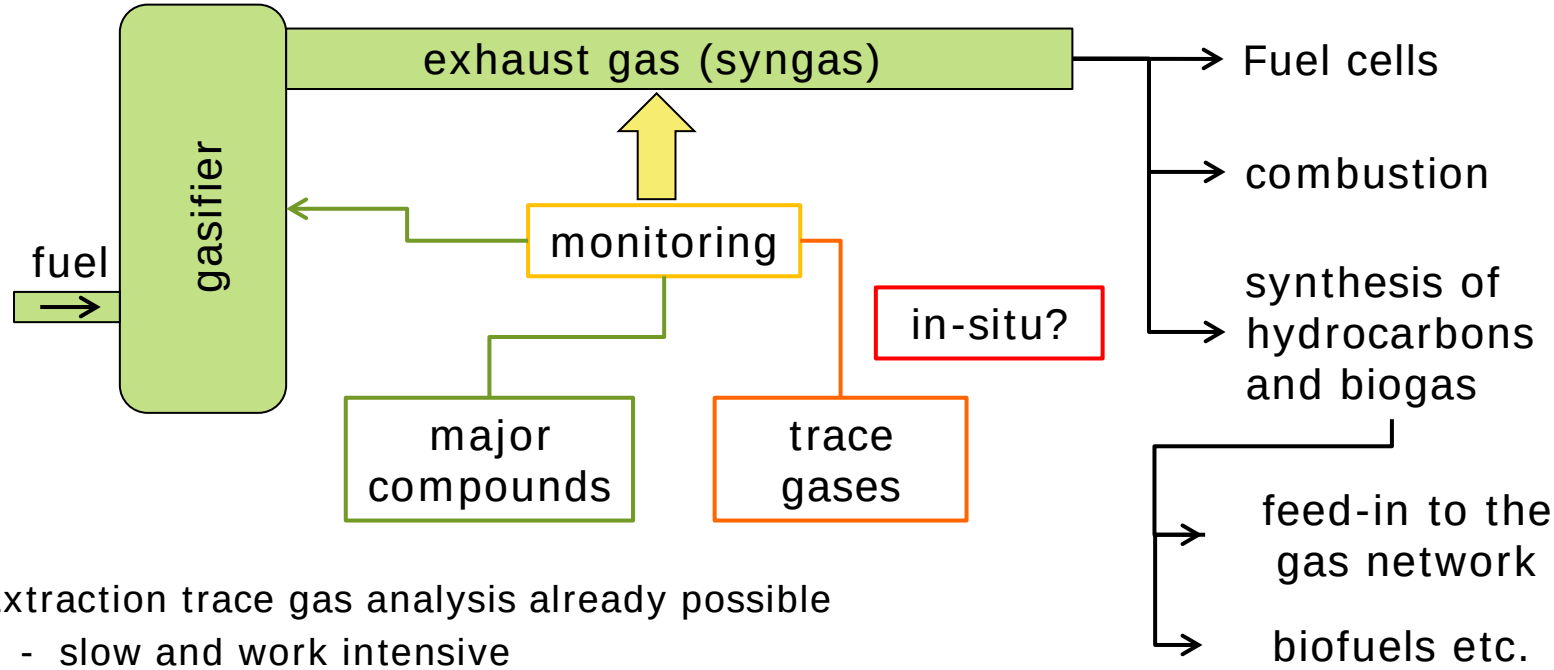


DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

Overview

- Motivation
- Scope of the PhD project
- Principles of the Techniques
- First field and laboratory experiments
- Outlook

Motivation: Improve Gas Quality



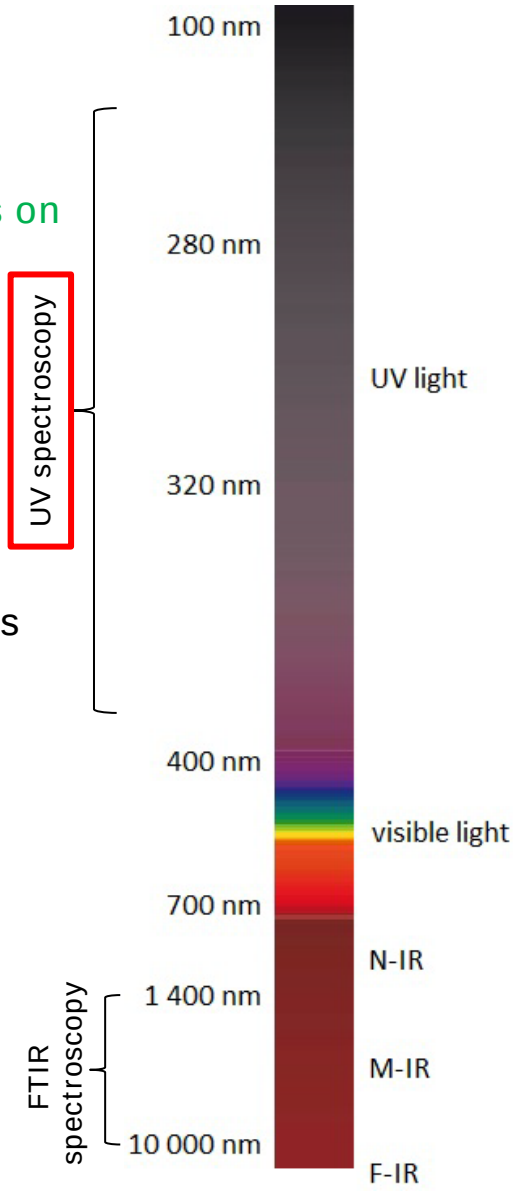
- Extraction trace gas analysis already possible
  - slow and work intensive
  - possible reactions after extraction

- On-line trace gas analysis
  - in-situ
  - fast response time

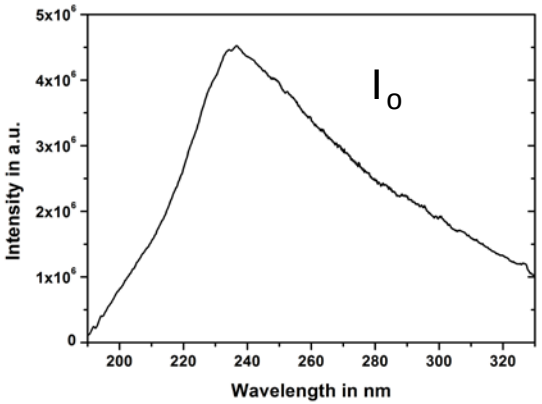
On-line trace gas measurement techniques for gasification

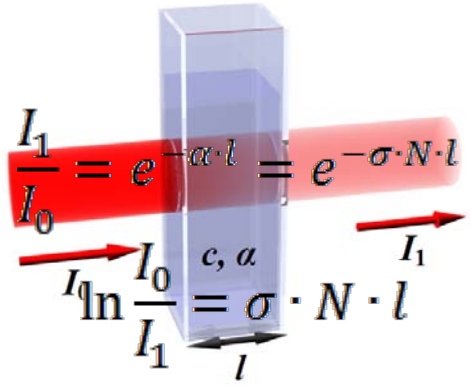
Scope: "... the development of trace gas in situ measurement technique which will be suitable for industrial applications on various types of gasifiers"

- Measurement techniques:
  - Fourier Transformed InfraRed Spectroscopy (FTIR)
    interesting compounds: H_2S, CS_2, NH_3, HCN, H_3CCl and (polyaromatic) hydrocarbons
  - Ultra Violet Spectroscopy (UV)
    interesting compounds : phenol naphthalene and other PAHs and inorganic compounds (H_2S, NH_3 etc.)
- Laboratory experiments
- Gasifier experiments
  - Low temperature circulating fluidised bed reactor (LT-CFB)
  - Two stage reactor VIKING (high temperature)
- Computation of spectra

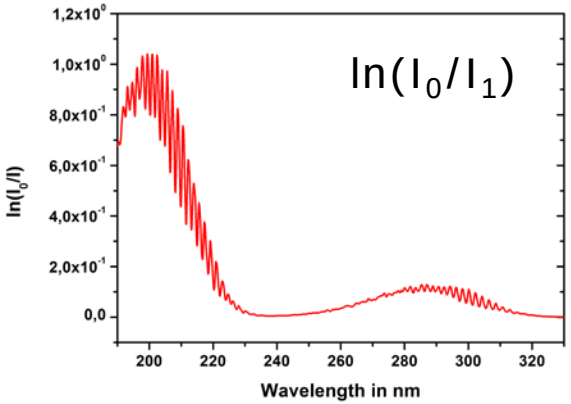


Principles of the UV Spectrometry





Lambert Beer law



UV source

Gas in a cell

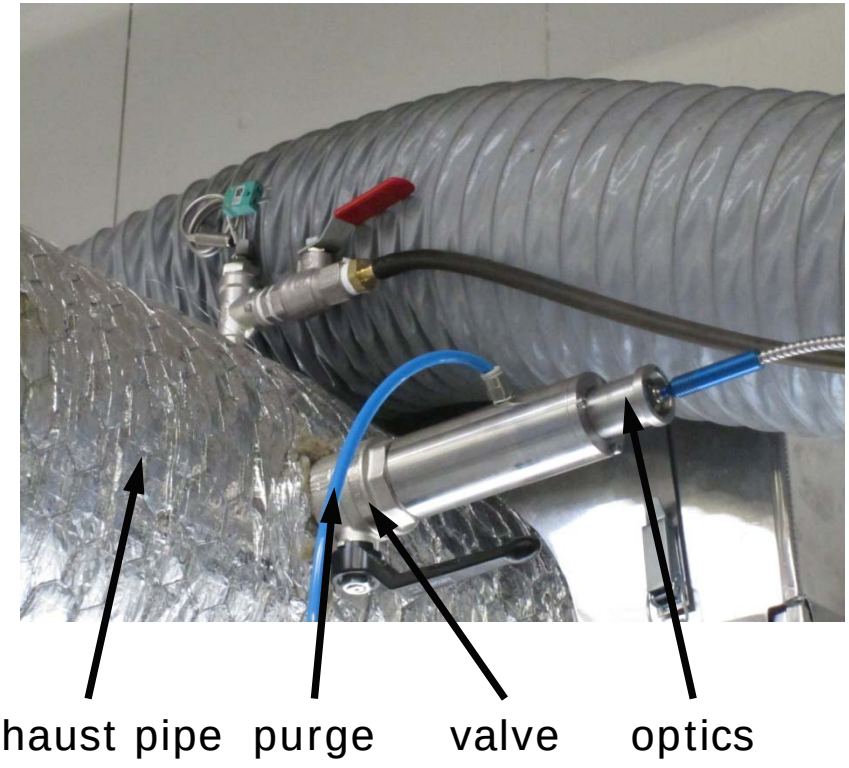
Spectrometer and CCD camera

The gasifier experiments

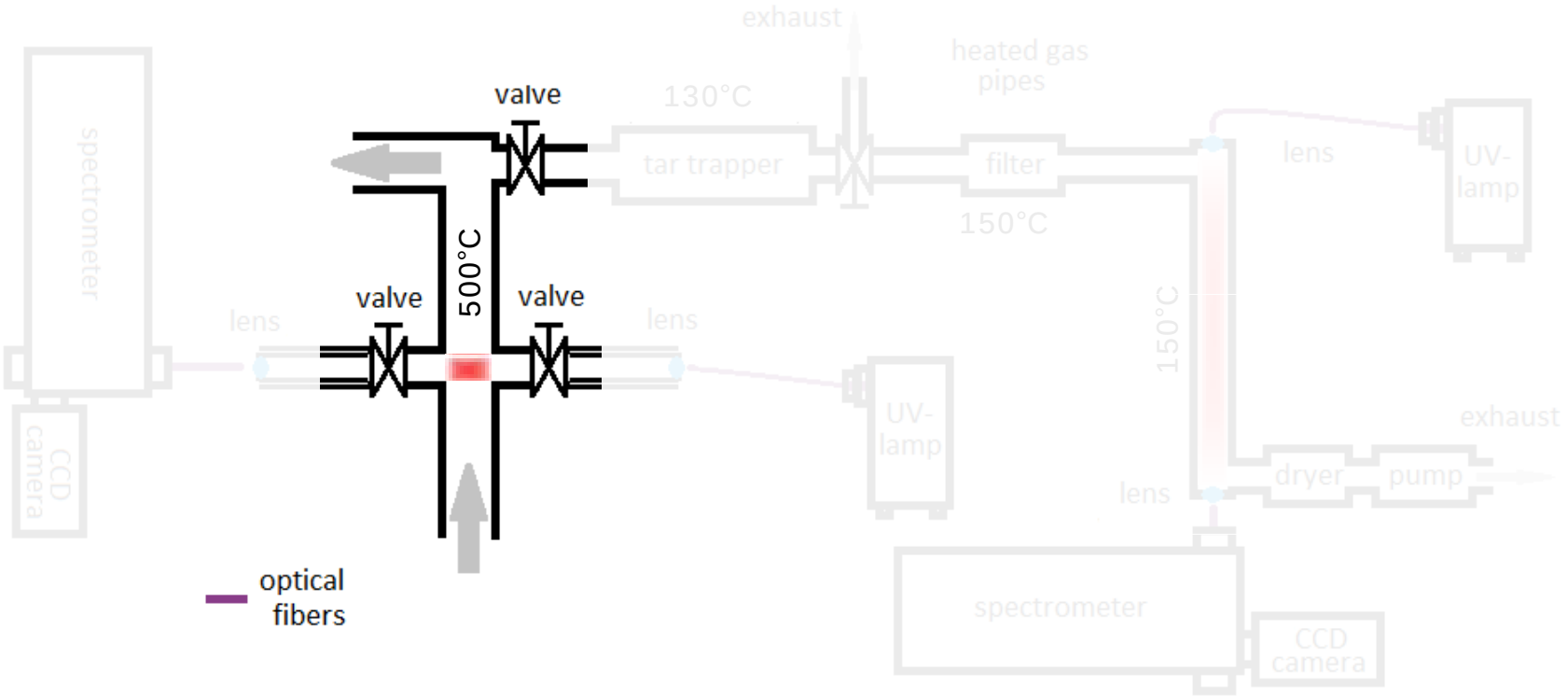
Purposes

- To get experience in the field
- To identify important compounds
- To compare extraction and in-situ (cross stack) measurements

cross stack measurements

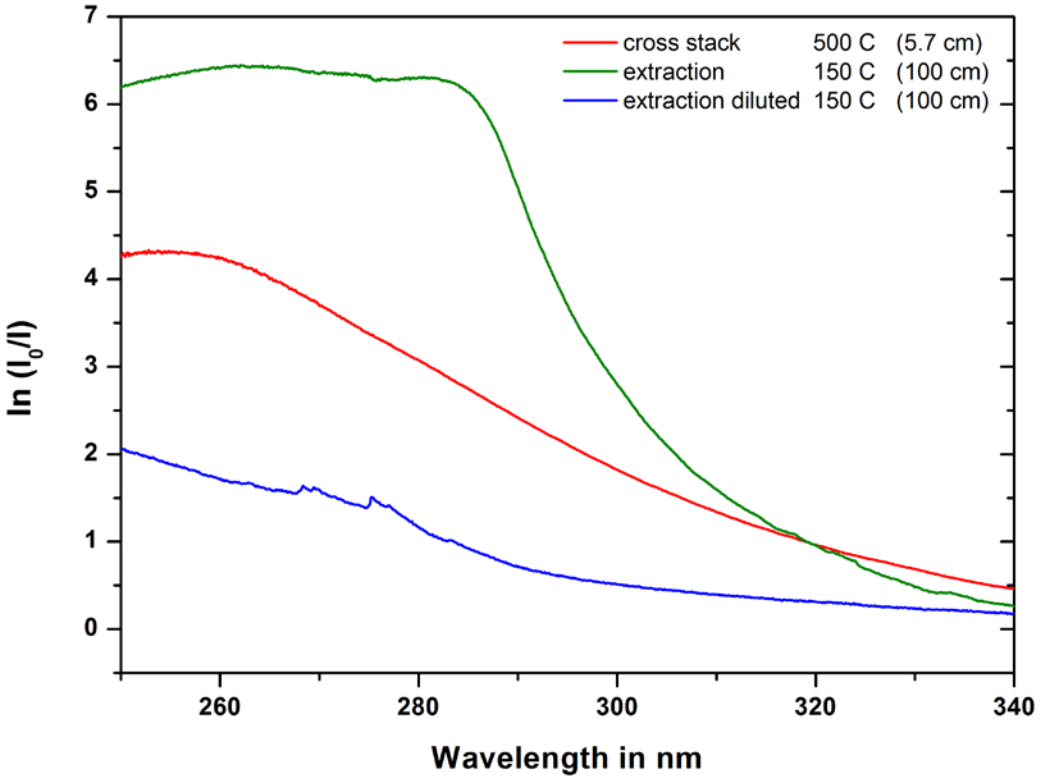


Setup at the gasifier



- One basic equipment (UV source, measuring zone, spectrometer, camera)
- In-situ with 5.7 cm pathlength
- Extraction with 100 cm pathlength
- Extraction with filtration of particles and heavy tars

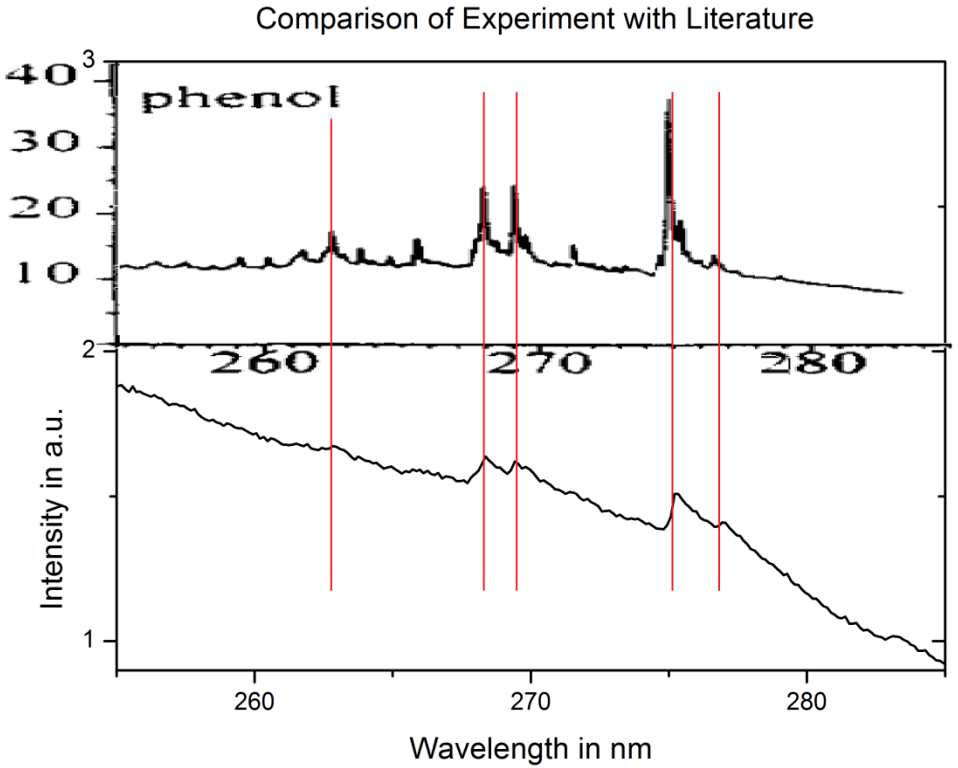
Results at the gasifier



Full absorption for extraction and cross stack measurements

BUT: appearance of structure at dilution

Results at the gasifier



Literature

Trost et. al.; Atmo. Environ.; Vol.31; No.23; 3999-4008; 1997

Resolution: **0.11 nm**

Temperature: **20.5 °C**

Experiment

Resolution: **0.335 nm**

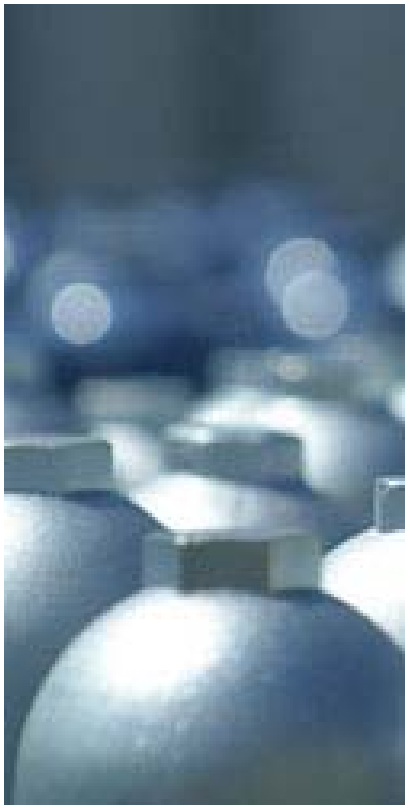
Temperature: **150 °C**

- Clear overlap of the peaks
  → Laboratory measurements with phenol at different temperatures

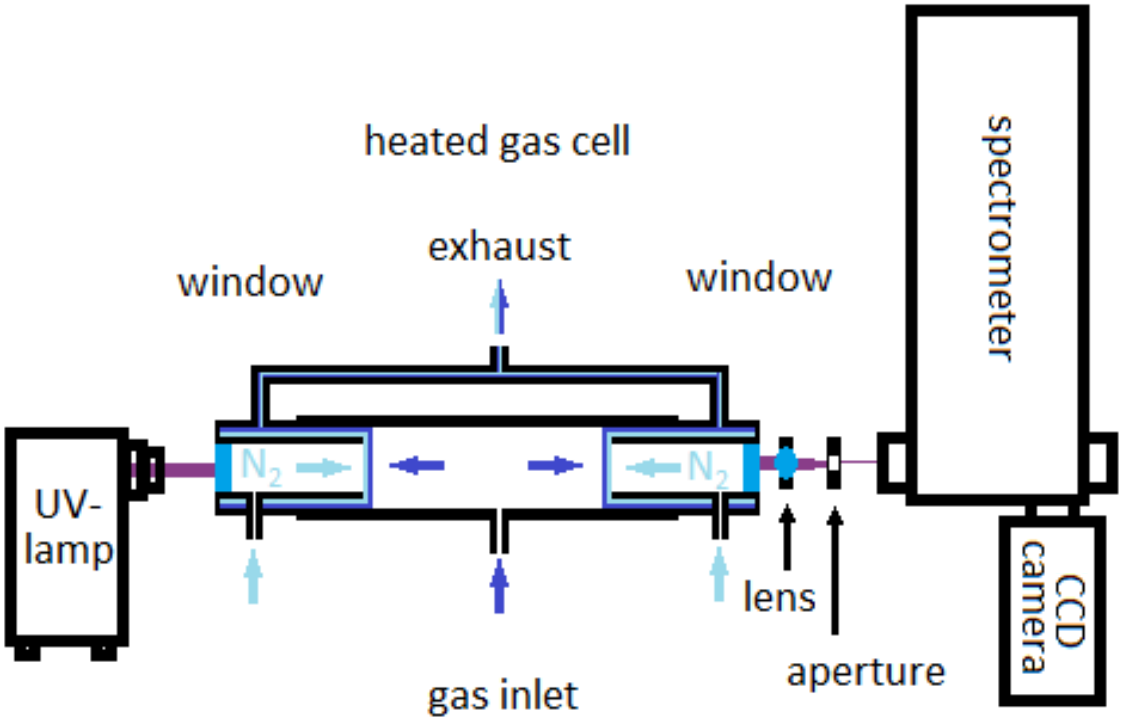
The laboratory experiments

Purposes

- Build up of high resolution database for different
  - Compounds
  - Temperatures
- Quantification of field experiments
- Validation of calculated values



Setup at the laboratory



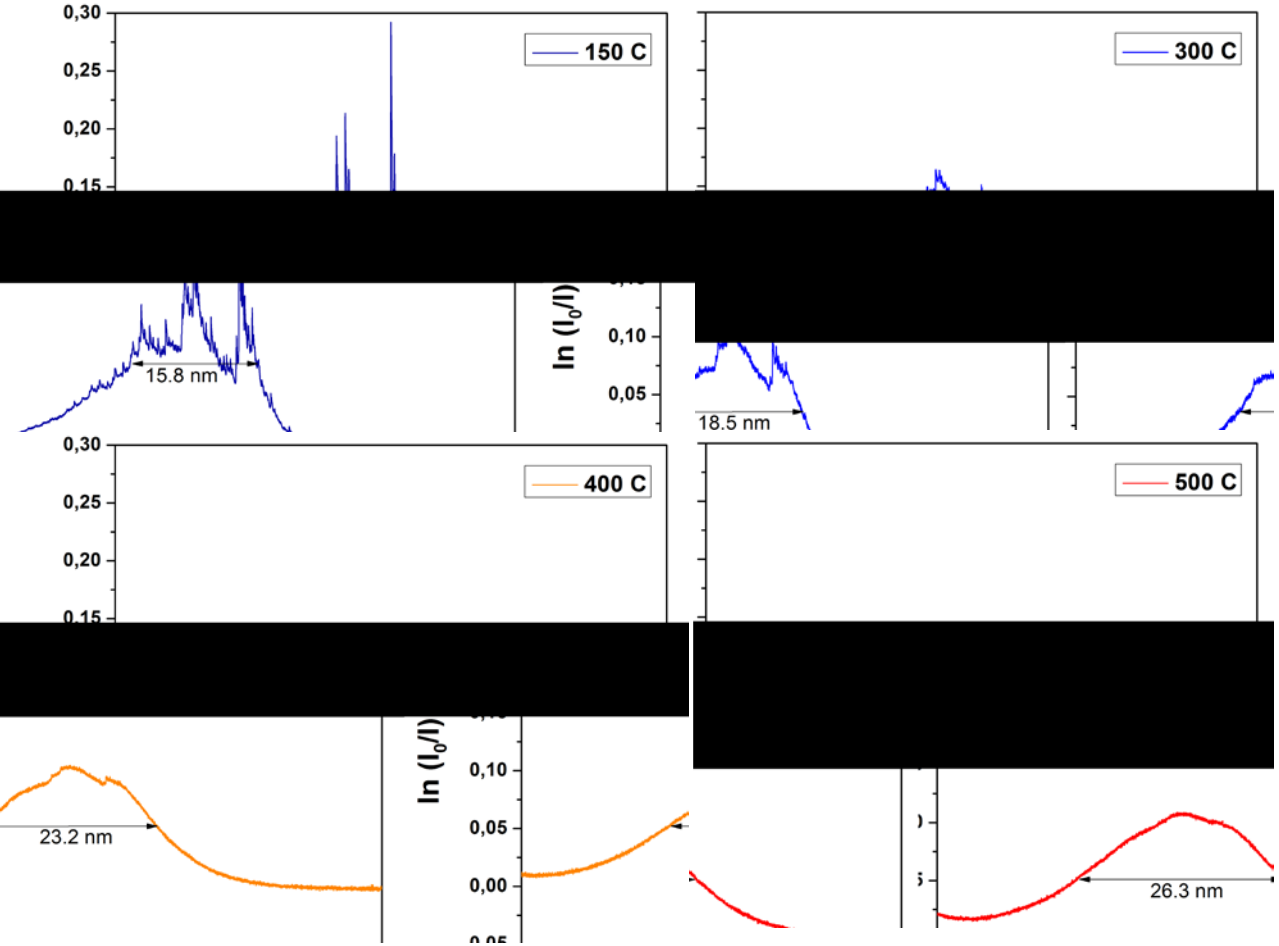
-Suitable for highly reactive gases

-Different gas mixtures/concentrations

-Temperatures up to 525 C

-Suitable for UV and FTIR

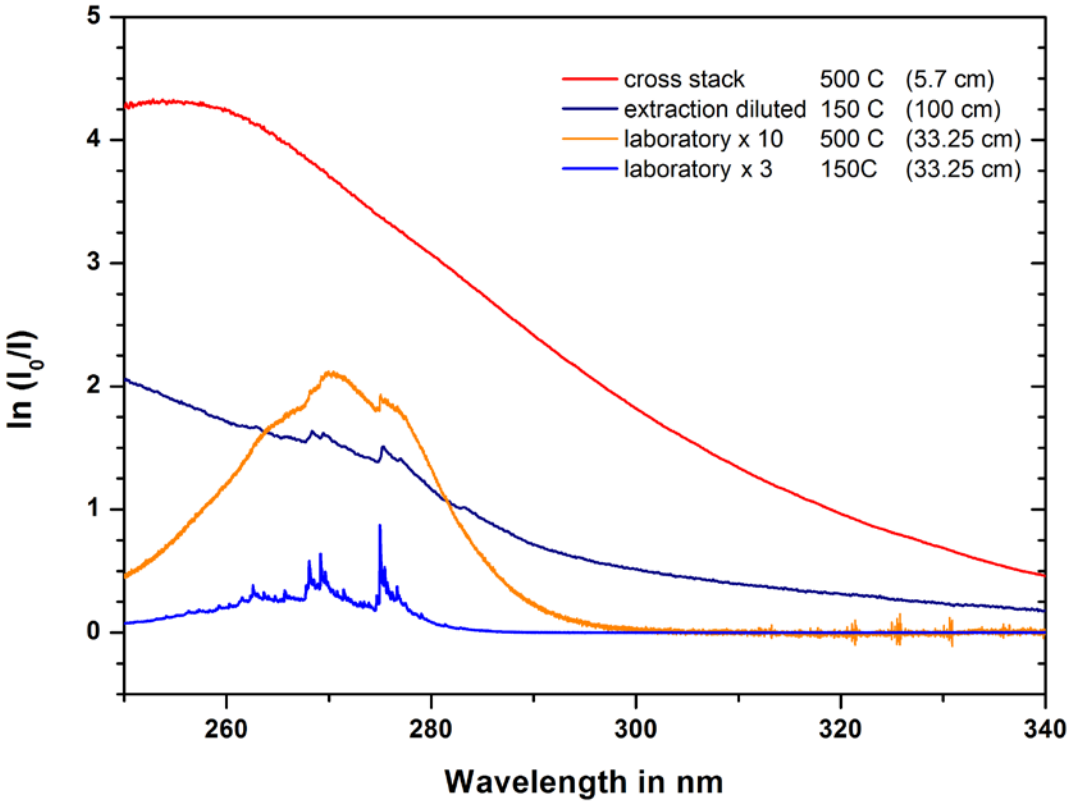
Results at the lab



- Resolution 0.019 nm or better
- Lower peaks at higher temperatures
- Broader structure at higher temperatures

=> Comparison with field experiments

Comparison Field - Laboratory



- Different concentration at both temperatures
- Overlay with other compounds (particles/2-4 ring PAHs)

⇒Recalculation of phenol values

⇒Identification of more compounds

⇒Comparison of concentrations with FTIR measurements

⇒Installation of particle filter

⇒Variable pathlength for lower absorbance

⇒Reduction of temperature

Conclusion

First results at gasifier

- Phenol identified as important compound (field experiments)
  => Experiments in the laboratory

First results in the laboratory

- Highly resolved phenol structure recorded at different temperatures
  => Comparison with field experiments

Comparison of both experiments

- Recalculation to different concentrations needed
- Identification and subtraction of other compounds necessary
- Comparison with FTIR
- Variable pathlength

Dec. 2011

June 2012

Outlook

Field experiments

- Next experiments on the way (including lower particle content)
- Different gasifier fuels
- Variable absorbance length
- Evaluation of other compounds

Laboratory experiments

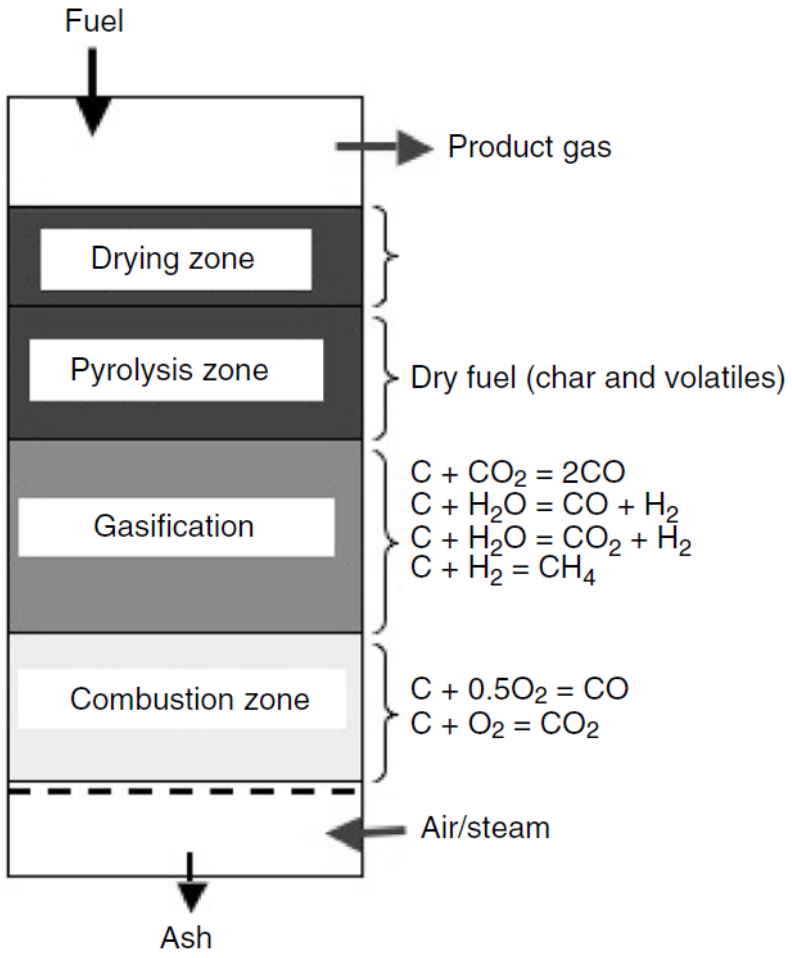
- Enlargement of database
- Build-up of synthetic exhaust for comparison
- Validation of computed values

Nov. 2014

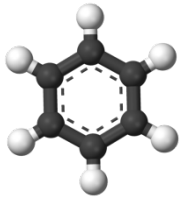
The End

Thank you for your attention!

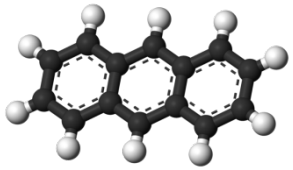
Add on 1: Gasifier stages



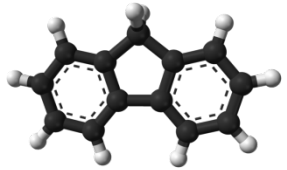
(Poly-)Aromatic Hydrocarbons



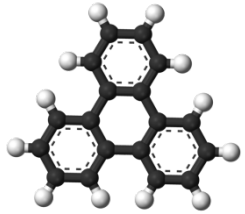
benzene



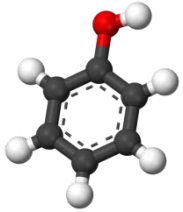
anthracene



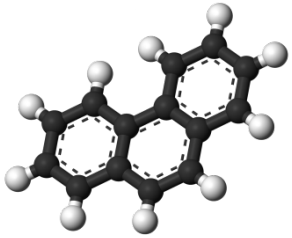
fluorene



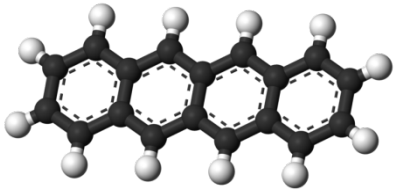
triphenylene



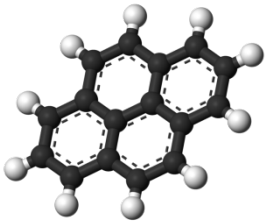
phenole



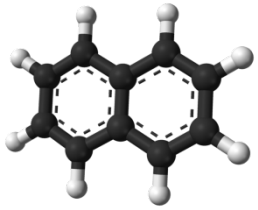
phenanthrene



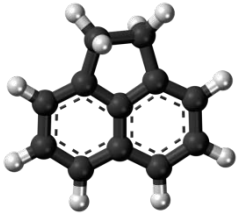
tetracene



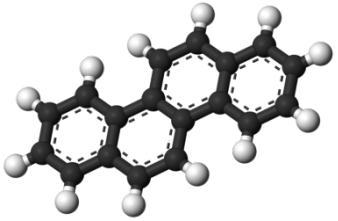
pyrene



naphthalene



acenaphthene



chrysene

ETC.